International Journal of Control and Automation
Vol. 9, No. 10 (2016), pp.237-246
http//dx.doi.org/10.14257/ijca.2016.9.10.23

Control System of the Miniature Automatic Precise Cutting Machine Based on PLC and Touch Panel

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Abstract

According to the control requirements of miniature precise cutting machine, this paper designs the control system of this cutting machine by the method of combing OMRON CP1H PLC and Eview MT506L touch panel. The control system uses PLC as its core, has completed in receiving the limiting I/O signal and upper computer communication signal and deals with the centralized processing according to the PLC interior design procedure and finally has realized the logic control of a frequency converter and three stepper motors. The touch panel is used for the man-machine intercommunication interface, completes the function of operation and display, and realizes the intellectualization and humanization of the cutting process. The experimental results show that the system is novel in design and has a friendly operation interface and advanced technology, can realize the high precision cutting of the workpiece.

Keywords*: Miniature automatic precise cutting machine, Control system, Touch panel*

1. Introduction

Miniature precise cutting machine is a kind of metallographic sample cutting machine, which is mainly used for the interception of metallographic samples and cutting of various materials. And the miniature precise cutting machine is widely used in machinery, metallurgy, automobile, aerospace and other fields, and it is one of the important equipment in the process of metallographic sample analysis [1]. At present, small precision cutting machine using touch panel and PLC as the control system is seldom both at home and abroad. In order to meet the requirements of the industry and promote the development of metallurgical industry, it is very important to design a metallographic cutting control system which has the characteristic of high precision, high performance and convenient operation [2]. According to the special requirements of metallographic sampling, combined with the actual situation in China and the international development trend, the control system of cutting machine based on PLC and touch panel is designed in this paper. The control system has realized the high precision cutting and the accurate lateral feed of the test piece, further enhanced the degree of automation and cutting precision, and has expanded the scope of cutting. The successful development of the miniature automatic precise cutting machine has greatly improved the level of automation in the field of Metallographic sample equipment industry.

In this paper, the control system of cutting machine based on PLC and touch panel is designed by means of the combination of mechanical and electrical, the combination of software and hardware, and increasing the function of flexible cutting. Among them, the touch panel completes the device's operation, display and

ISSN: 2005-4297 IJCA

other functions; and the PLC is used to prepare the procedures for the control of equipment according to the requirements of the production process. The control system of miniature automatic precise cutting machine is designed by the method of combing OMRON CP1H PLC and Eview MT506L touch panel in this paper. The experiment shows that the system has the characteristics of good man-machine interface, perfect monitoring function, protection measures, convenient operation and reliable performance.

2. Working Process of the Miniature Automatic Precise Cutting Machine Based on PLC and Touch Panel

The cutting process of the miniature automatic precise Cutting machine is divided into the following three steps:

(1) System startup: Firstly, various cutting parameters and the cutting mode are set in the touch panel window. Then press the start button, Logic control part of the cutting machine sends out the control signal, so that the three-phase asynchronous motor is started and the grinding wheel is rotated. In the corresponding cutting mode, the working platform is moved to the set cutting position, and then the Z-direction stepper motor is started, which makes the grinding wheel move downward to prepare cutting. In this process, the running state of the cutting machine is returned through the monitoring part, and is displayed on the touch panel window.

(2) Normal cutting: When the grinding wheel moves to the specified position above the workpiece, the grinding wheel will cut the workpiece according to the set feed rate.

(3) Cutting end: When the work is finished, the logic control part sends out the signal, so that the three-phase asynchronous motor stops rotating and the grinding wheel stops rotating. At the same time the Z-direction stepper motor control the grinding wheel upward movement, the whole cutting process is finished when the grinding wheel reaches the limit.

3. Hardware Design of the Control System

3.1. Overall Structures

The hardware of the control system is mainly composed of five parts: touch panel man-machine interactive module, PLC control module, inverter induction motor speed control module, stepper motor subdivision driver, real-time speed and position feedback module. The PLC control module is the core of the system control, which can solve the problem of data processing of the input signal and output logic sequence control, and the setting and display function of the system parameters are completed by the touch panel human-computer interaction module. The motion execution component of the control system is mainly a main motor (three phase asynchronous motor) and three control motors (X/Y/Z-direction stepper motor). PLC should be simultaneously controlled three stepper motors subdivision driver and a frequency converter to complete the cutting action.

When the system is running, the touch panel sends the control information (grinding wheel diameter, grinding wheel rotational speed, rocker arm and worktable feeding speed, cutting mode, *etc*.) to the PLC through the serial port. The control signal is sent out to the frequency converter and the stepper motor subdivision driver by the PLC that according to the user's selected cutting mode and set the cutting parameters and the Position signal of proximity switch detection, so that the worktable, rocker arm and the grinding wheel coordinate exercise and complete the cutting task. During the cutting process, the feedback information of the operating parameters and the working state of the relevant components is displayed on the

touch panel dynamically through the real-time speed and position feedback module. If an exception occurs, it will automatically alarm, touch panel display system fault information.

The system block diagram is shown in Figure 1:

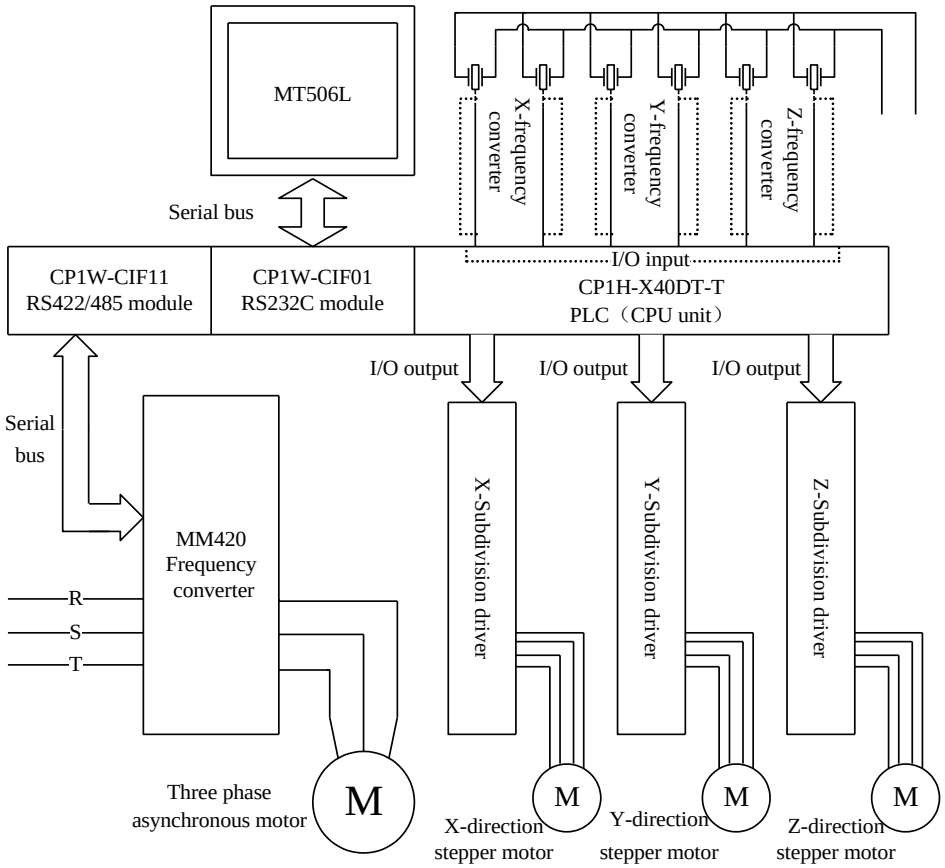

Figure 1. System Block Diagram

3.2. Interface Circuit of PLC and Stepper Motor Driver

In order to meet the feed requirement of cutting machine, the special subdivision driver is used to drive the stepper motor. Z-direction stepper motor controls the movement of the rocker arm through worm to complete the fast-forward, rewind and intelligent cutting tasks. Y-direction Stepper motor controls the vertical reciprocating motion of the working table through the screw nut and to complete the task of cutting width. X-direction stepper motor controls the transverse motion of the working table through the screw nut and to complete the task of cutting length. PLC control system needs to provide appropriate control signals to enable asynchronous motors and stepper motors coordinated motion and complete the prescribed cutting action.

This design chooses CP1H-X40DT-D PLC that is the Japanese OMRON company's product. And it is a transistor drain type output, its I/O number is 40, the DC input point is 24, the transistor output point is 16 [3]. Stepper motor and its driver are selected shanghai guruojin company's products, models are 57BYH250A and 2HB504MA. 2HB504MA driver's dial switches is 10 bits. Among them, 1-4 bits is used to set the drive's fine fraction and is set to "1100" (64 subdivision, step angle 0.028125°); 8-10 bits is used to set the drive's output current and is set to "111"

(4A); the fifth bit is used to set the control signal mode, "0" is the PUL/DIR way, "1" is the CW/CCW way; 6-7 bits is used to set quiescent current. PLC and driver are connected with common anode mode, so that the "DIR+" and "PUL+" are connected to the positive electrode of the external power supply, "VCC" is connected to the +40V power supply, "AC40V/4A" is the driver power. The wiring diagram of PLC and driver is shown in Figure 2.

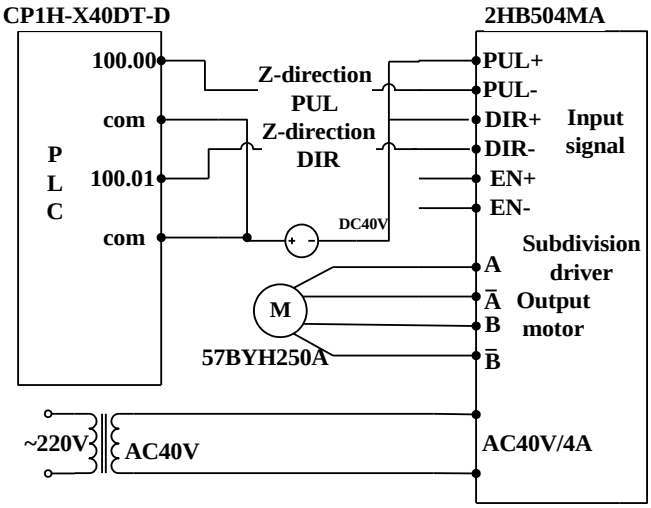

Figure 2. Wiring Diagram of PLC and Driver

3.3. Control Circuit of Frequency Converter

Because the rotating speed of the grinding wheel has a great influence on the quality of the cutting sample, the grinding wheel piece should have different speed when cutting different samples. The speed of grinding wheel is higher when cutting a sample with high hardness and the speed of the grinding wheel is lower when cutting copper, aluminum and other soft samples. In order to get the rotating speed of the grinding wheel with a wide range of adjustment, it is necessary to carry on the frequency conversion timing to the asynchronous motor. The rotating speed of the grinding wheel piece can realize the stepless adjustable 0-2000r/min through the frequency conversion timing of the asynchronous motor. Frequency conversion timing technology was adopted to control the asynchronous motor to attaining stepless timing, so the flexibility of cut different material was boosted up. The control mode of PLC to frequency converter is used in RS485 serial communication [4].

(1) Main circuit of frequency converter

Frequency converter R, S, T is the input side, after the leakage protector connected to the 380V/50HZ three-phase AC power supply. U, V, W is the output terminal, connected to the AC motor. The change of the frequency converter output setting frequency will control the change of the speed of the main motor, the relationship between the two is approximately linear, and the goal of stepless speed regulation can be realized. In order to ensure the normal operation of the system, the grounding end of the transducer should be reliably grounded.

(2) Connection between frequency converter and input control signal

PLC uses the RS485 serial communication way to control the frequency converter; the serial port output of PLC is connected with the serial port output of the frequency converter. The output of the PLC SDA and SDB connect in series, and

then connect the output terminal P + of the frequency converter after a 1.5K resistance; the output of the PLC RDA and RDB connect in series, and then connect the output terminal N − of the frequency converter after a 470Ω resistance; finally, a 120Ω resistor is connected between P + and N − .

Frequency converter has intelligent external connection terminal board. Among them, 1-4 terminals are used to control motor input frequency; terminal 5 − motor forward operation; terminal 6 − motor reverse operation; terminal 7 − fault reset. Multi speed selection output control can be composed if the terminals 5, 6, 7 and common terminal 8 are used in combination. The specific control wiring is shown in Figure 3.

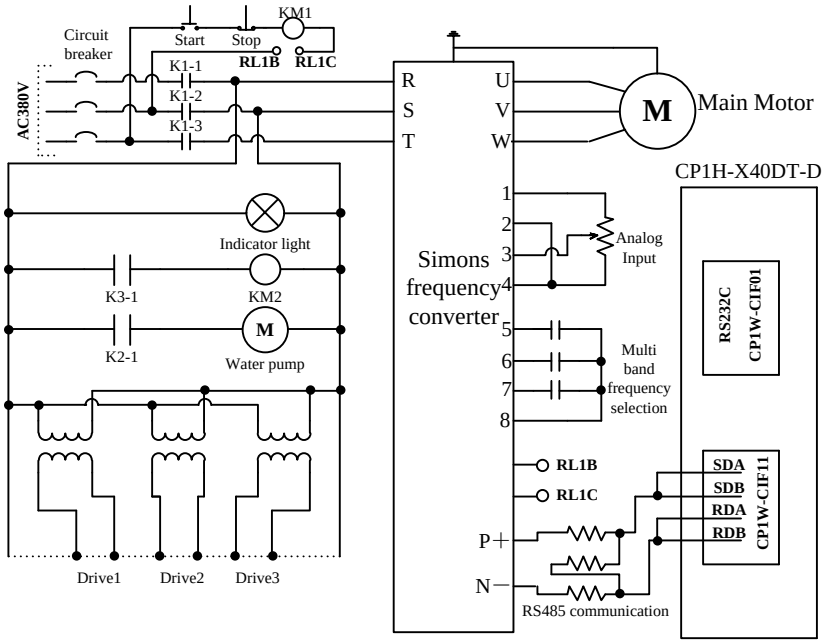

Figure 3. Electric Principle Diagram of Frequency Transformer Control

4. Software Design of the Control System

The process of control system controlling the cutting is as follows: first, the entire system is initialized; secondly, total distance Z of grinding wheel up and down movement and total distance Y of grinding wheel front and rear movement are measured by entering the test program before the first start of the machine, and the values are stored in the ROM of PLC to be used in the subsequent cutting process; then select the cutting mode subroutine, including manual control and automatic control. The main program flow chart of control system is shown in Figure 4:

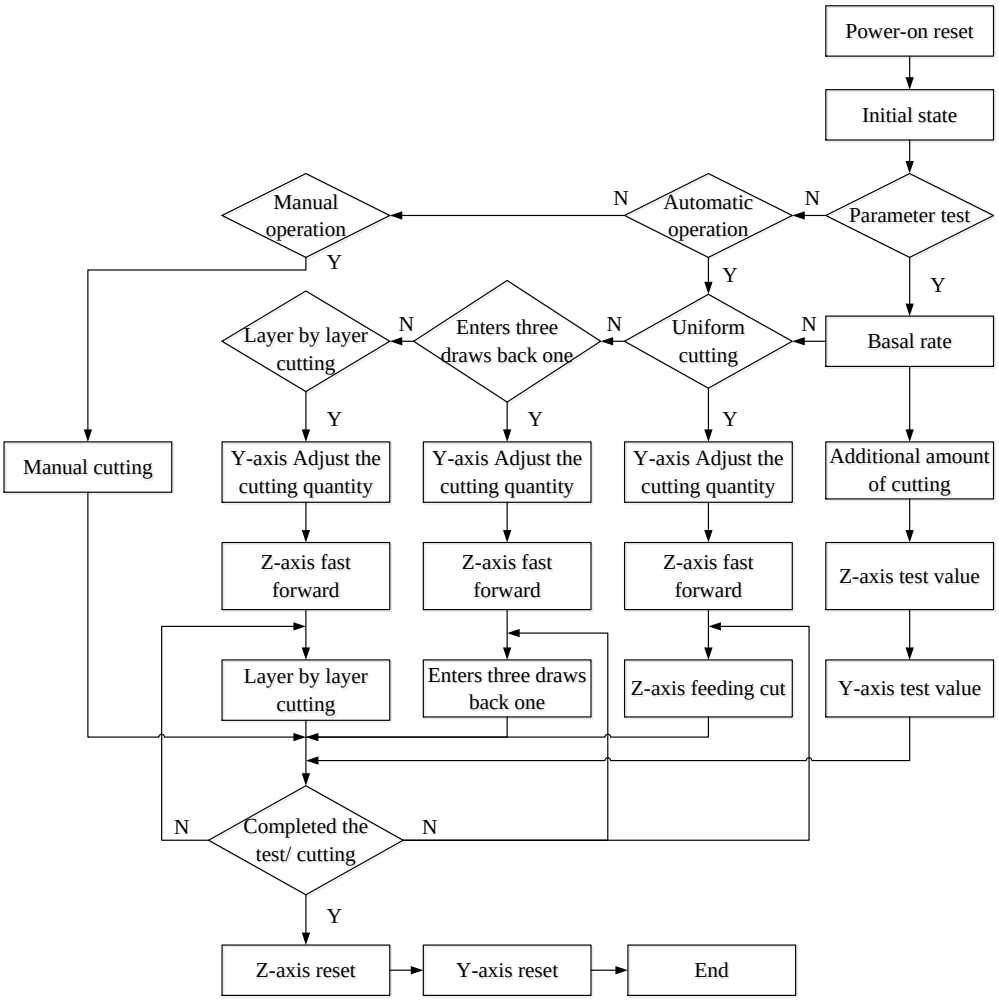

Figure 4. The Main Program Flow Chart of Control System

Among them, the initialization mainly includes: the initialization of the I/O port mode; the initialization of timer mode and timing; the initialization of RAM unit within the PLC; the initialization of external interrupt and interrupt control. The initialization makes the PLC and its peripheral circuits in a state of preparation.

Furthermore, the cutting method subroutine includes two operation modes, including manual control and automatic control. Among them, the automatic control method includes three kinds of cutting modes: uniform cutting mode, layer by layer cutting mode, enters three draws back one mode. After selecting a cutting mode, the system control mainly completes the cycle monitoring of the input state and the external interrupt, and then turns to the corresponding branch of the program the for each specific case. The branches of these procedures include: stepper motors subdivision driver control procedures, automatic intelligent cutting control procedures and frequency converter serial control procedures, etc.

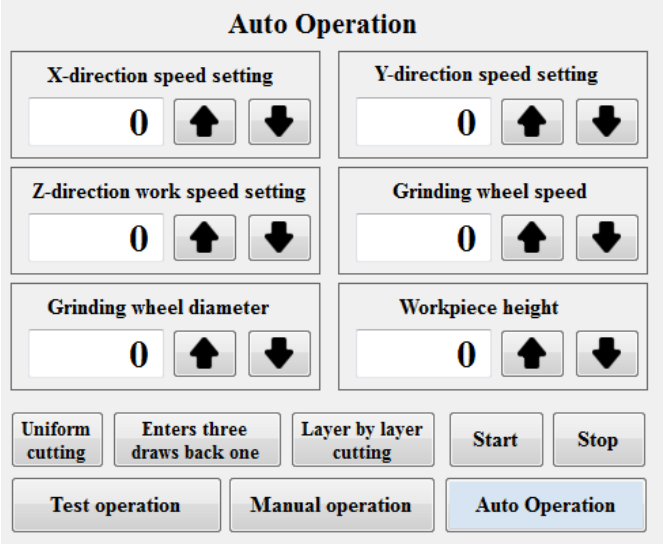

Figure 5. Interface of Auto Operation

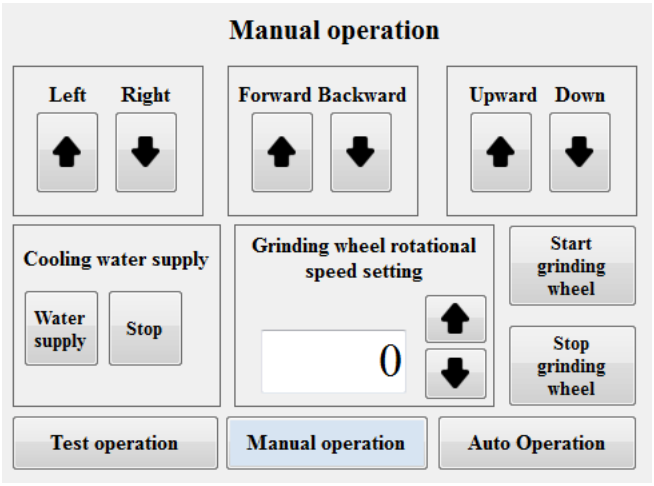

Figure 6. Interface of Manual Operation

5. The Design of Touch Panel Operator Interface

This system uses Eview MT506L touch panel, its editing software EasyBuilder 500 powerful, easy to use, can easily complete the design of man-machine interface and online complex simulation function [5]. Due to the application of touch panel, this system eliminates the switches, buttons, lights and instrumentation in the traditional control method and reduces the PLC's I /O points, the wiring and the volume of the control cabinet. The man-machine interface achieves setting various cutting parameters and dynamically displaying the control information that improves the ability of human-computer interaction system. At the same time, the system designs animation display of the cutting process, so that the whole process is clearly visible. The touch panel with good human-machine interface, perfect monitoring functions and protection measures, not only convenient operation, and make the performance of the system more safe and reliable.

According to the system control and operation requirements, touch panel is designed five major human-computer interaction interface, including the initial

interface, test operation interface, auto operation interface, manual operation interface, cutting process display interface, etc.

After the power supply to the system, touch panel automatically enters the initial interface. In the initial interface, the operator can view the system operation instructions through the help menu and select the work mode from test operation, manual cutting and automatic cutting. The user presses the "Test operation" button to enter the test touch interface, and can set the speed of test and reset. The test results will be displayed in the test interface after the test operation, and provide reference for formal cutting. The user presses the "Auto Operation" button to enter the auto operation interface, and select the cutting modes from uniform cutting, enters three draws back one and layer by layer cutting. After cutting mode is selected, the users set the cutting parameters, and then press the start button to begin automatic cutting. In the cutting process, touch panel automatically enters the cutting process display interface. The operating parameters and the working state are dynamically displayed on the touch panel, and the touch panel display system fault information when abnormal situation. The user presses the "Manual operation" button to enter the manual operation interface, and set the Grinding wheel rotational speed and feed rate of three directions, and then can operate the touch button to control the single step cutting movement. In the process of manual cutting operation, at any time the user can access the parameter display interface to view the current cutting parameters, and can enter the parameter setting interface to adjust the cutting parameters.

The auto operation interface is shown in Figure 5 and the manual operation interface is shown in Figure 6.

6. Conclusions

The control system of the cutting machine has been designed by the method of combing OMRON CP1H PLC and Eview MT506L touch panel in this paper. The touch panel as the human machine interface in this system has achieved setting various cutting parameters and dynamically displaying the control information that has improved the ability of human-computer interaction system. At the same time, the system has designed animation display of the cutting process, so that the whole process is clearly visible. The experimental data has showed that the positioning accuracy of precision cutting machine can reach to 8 um, the maximum moving distance can reach 250mm and Z-direction feed rate is 1-20mm/min. The test has showed that the high precision cutting of workpiece can be implemented through stepper motor controlled by PLC.

Acknowledgements

This work was supported by Baoding Science and Technology Research and Development Project (11ZG029).

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